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Robert E. Dunne
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Kennecott

July 19, 1994

M/035/015

John Whitehead
Ground Water Protection Section
Division of Water Quality
288 North 1460 West
Salt Lake City, Utah 84116

Dear Mr. Whitehead

Subject: Supplemental Data Submittal Requested for Tailings Impoundment Groundwater Discharge Permit Application

Attached is a summary analysis of the potential for acidification of the tailings and the susceptibility of clays beneath the impoundment to being altered by tailings water that could emanate from the impoundment. This analysis was prepared for Kennecott by Dr. Don Runnells of Shepherd Miller Assoc. of Fort Collins, Colorado in response to your letter dated June 30, 1994 requesting the analyses.

Portions of the water quality data, also requested from the Chevron Properties Area is under going our required quality assurance review. This review should be completed this week. A summary of the water quality data for which the quality assurance review has been completed is attached. The remaining analyses will be submitted as soon as they are available. Kennecott has previously provided the drawings requested in the above referenced letter. The anaylsis of the water balance requested is still in preparation, but should be completed by the weeks end (July 22, 1994).

Finally, a report discussing the location and extent of possible penetrations into the Bonneville clay has been prepared and is in the final stages of the review process. It is anticipated that this report will be issued next week.

If you need any additional information or clarifications, please contact Ric Jones at #569-6640 or myself.

Sincerely,

Robert E. Dunne

/jbf

cc: File

SMI
Shepherd Miller, Inc.

MEMORANDUM

TO: Ric Jones

FROM: Donald D. Runnells, Michael J. Shields

DATE: July 15 1994

RE: Neutralization of potentially acidic water by strata under the KUC Impoundment

The following is a discussion of an analysis performed to determine the potential for Kennecott Utah Copper (KUC) tailings to be oxidized and to cause acidification of the underlying shallow aquifer.

Chemical testing is currently being conducted to determine the potential for acidification of the tailings. The testing results to date include acid/base accounting (ABA) on approximately 90 samples from four drillholes on the margins of the KUC Impoundment and 170 shallow subsurface samples from transects on the embankment. Long-term kinetic testing is also being conducted on two samples of tailings.

The ABA results show that core samples of tailings from the four drillholes range from a value of a moderately acidic -26 tons $CaCO_3$/1000 tons to a moderately alkaline +14 tons $CaCO_3$/1000 tons. Samples from the embankment have a broader range, from moderately acidic -63 tons/1000 tons to strongly akaline +175 tons $CaCO_3$/1000 tons. The mean values of the core samples and the embankment samples are very similar, -4.3 tons $CaCO_3$/1000 tons and -0.19 tons $CaCO_3$/1000 tons, respectively, both of which are marginally acidic to neutral. Long-term kinetic testing on one slightly acidic sample and one alkaline sample shows that the rate of acidification, if it occurs at all, will be very slow. Additional kinetic sampling will probably be conducted as appropriate. Mineralogical studies will also be undertaken in the near future to attempt to identify the minerals that are reactive in the acid/base chemistry.

If acid is generated, neutralization will occur when the acid encounters the carbonate-rich sediments of the underlying shallow aquifer. Chemical characterization of the underlying strata indicates that it has a high neutralizing potential and would act as a pH buffering medium. The following calculations are carried out to evaluate the neutralizing potential of this material.

The first step in the analysis is the determination of the amount of acid that could potentially be produced by the tailings material. As mentioned above, the average ABA value for core samples of tailings is -4.3 tons $CaCO_3$/ktons of material, and the average ABA value for samples from the embankment of the Impoundment is -0.19 tons $CaCO_3$/kt. The more negative value, which represents a greater potential to produce acidity, is used in the following computations. The KUC Impoundment contains approximately 1.5 billion tons of tailings and covers an area of approximately 2.61×10^8 ft^2. After making the appropriate conversions, the calculated total amount of potential acidity that could be released is equivalent to 6.45×10^6 tons of $CaCO_3$.

Analyses of 111 samples of soil and shallow aquifer material from sites around the KUC Impoundment (Bio/West, 1993) show a high content of calcium, with an average value of 84,037 mg/kg Ca. The calcium content is probably contained in two forms: (1) calcium as solid $CaCO_3$ and (2) calcium ions adsorbed to surface sites on clays. Therefore, to calculate the amount free calcium carbonate contained in the material it is necessary to subtract the amount of calcium that may be adsorbed to the clays, using the following formula:

$$\text{free Ca} = \text{total Ca} - \text{Ca adsorbed to clays}$$

where

total Ca = mass of strata x Ca concentration

Ca adsorbed = mass of strata x cation exchange capacity

mass of strata = depth x area x density.

Calculation of the total mass of the underlying strata requires the assumption of an appropriate thickness. The shallow aquifer is generally thought to be about 50 feet thick and, therefore, for the purposes of these calculations, a depth of 50 feet was assumed. The density of the material,

92.35 lb/ft^3, is an average of the reported values from a report on the shallow aquifer by the U.S. Geological Survey (Thiros, 1992). Multiplying the area of the Impoundment times the thickness and density of the strata immediately beneath the Impoundment, the resulting mass of material is calculated to be 5.49×10^{11} kg.

As mentioned earlier, the total concentration of calcium, which includes both calcium on exchange sites and as free $CaCO_3$, is 84,037 mg/kg. The total amount of calcium is calculated to be 4.61×10^{16} mg. The average cation exchange capacity (CEC) of the shallow aquifer material is calculated to be 15.1 meq/100 g (Thiros, 1992). Assuming that all of the exchange sites on the clays are occupied by calcium, and using this value together with the total mass of the aquifer to a depth of 50 feet, the total amount of calcium bound by clay in the strata is calculated to be 1.66×10^{15} mg. Subtracting the value of exchangeable calcium from the total calcium value results in 4.44×10^{16} mg of free calcium.

WHY

Assuming that the free calcium is all present as calcium carbonate, and multiplying by the conversion factor of 2.5, the total mass of calcium carbonate is 1.11×10^{17} mg, or 1.2×10^8 tons of $CaCO_3$. In comparison, as described above, the equivalent mass of $CaCO_3$ that could be consumed by the potential acidity in the KUC Impoundment is 6.45×10^6 tons. Therefore, for a depth of 50 feet immediately beneath the Impoundment, there is approximately 19 times more capacity for neutralization of acid by solid $CaCO_3$ than the total amount of acid that could potentially be released from the entire KUC Impoundment. Stated in a different way, the results indicate that all of the acid that might be produced by the entire mass of KUC tailings would be entirely neutralized by the neutralization capacity of a thickness of approximately 2.6 feet of the underlying natural substrates.

ASSUMED

REFERENCES

Bio/West, Inc., 1993, Environmental baseline monitoring for the Great Salt Lake area of operations, Volume VI, Draft Summary Report: Prepared for Kennecott Utah Copper Corporation

Thiros, S.A., 1992, Selected hydrologic data for Salt Lake Valley, Utah, 1990-92, with emphasis on data from the shallow unconfined aquifer and confining layers: U.S. Geologic Survey Open-File Report, 60p., 1 map sheets.